MANUAL

TO ACCOMPANY THE

STAR GLOBE

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J. Davis

MANUAL

TO ACCOMPANY THE

STAR GLOBE,

CONTAINING A COMPLETE COURSE

—OF—

Problems and Illustrations

OF THE

FUNDAMENTAL PRINCIPLES

—OF—

GEOGRAPHY,

29/5662

FOR THE USE OF

Teachers, Schools & Families,

SEP 29 1884
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CITY OF WASHINGTON.

—BY—

REV. JOHN DAVIS, A. M.,

AUTHOR OF THE "ELEMENTS OF ASTRONOMY,"

ALLEGHENY CITY, PA.

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PREFACE.

The object of this Manual is to conduct and aid pupils by a brief, easy and natural way in obtaining a correct knowledge of the Principles of Geography. Its pages are not multiplied, as is frequently the case, with matter that properly belongs in general text books, but are confined to presentations and illustrations of the elements of the subject under consideration. It leads the pupil step by step to consider and observe by practical demonstrations on a *Terrestrial Globe*, how the principles of Geography are related and combined, so as to form the basis of the Science. The spherical shape of the Globe itself, and all of the natural divisions of the Earth having their counterparts marked on the map that covers it, tend to this end, so also do the lines and circles which are drawn thereon, whereby distances may be measured and places located and described. The Essentials of the Science being grouped together on the Globe in their proper relations, *The Manual* presents a comprehensive series of Problems and Examples whereby the pupil may have a vivid exemplification of their meaning, and thereby arrive at the full measure of that instruction which underlies this department of mental culture.

The Author while preparing this Manual, carefully consulted the best English, French and American Authorities on the use of Globes, with the view of having it simple, brief and at the same time sufficiently comprehensive for the purpose for which it is designed.

The Definitions and Explanations which relate to the subjects considered in this Manual are, for the sake of convenience placed after the Illustrations and Problems. And in connection with each of the Illustrations and Problems reference is given to such Definitions and Explanations as should be studied with care before entering upon its solution.

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Letters representing the principal parts of the Star Globe.

T. The Tripod. I. The Hour Index. S. The Spiral Springs.
M. The Meridian. P. The Polar Bearings.
B. The Meridian Bearing. Q. The Quadrant.
H. The Horizon. G. The Globe.

Directions for putting the parts together.

1st. Insert the shaft of the Meridian Bearing B, in the socket of the shaft of the Tripod T, and turn the screw in the Tripod till it comes in contact with the shaft of the Meridian Bearing B.

2nd. Drop one of the two Spiral wire-springs S, into each end of the tubular axis of the Globe and put the Hour Index marked South on the South Pole, and the one marked North on the North Pole, and follow the Spiral wire-springs into the ends of the tubular axis of the Globe, with the shafts of the Polar Bearings P.

3rd. Place the groove in the outer end of one of these Bearings, on the inside of the Meridian M, and remove the small plate on the end of the other Polar Bearing, with a small screw driver, (taking care not to lose the very small rollers through which the screws pass.) and press the Polar Bearing towards the center of the Globe till it takes its place on the inside of the Meridian M, and then replace the small plate which was removed from the Polar Bearing, and the Globe is ready for use.

STAR GLOBE.

STAR GLOBE.

(Diameter 12 inches.)

The Star Globe, being complete in all its appointments, contains elements of UTILITY and DURABILITY which are not found in any other. Unlike many others, that are now being made without a Graduated Meridian, or Hour Indices, or Quadrant of Altitude, or Horizon, it possesses all of these parts, and all others which are essential either for convenience or instruction.

GLOBE STAND.

The Globe is mounted on a metallic Tripod, which is light, substantial, convenient, neatly japanned, and tastefully ornamented.

MERIDIAN.

The Meridian which contains the Globe is brass, plated with nickel, and GRADUATED ON BOTH SIDES. One-fourth of its circumference is inserted in a concave metallic bearing to give it permanence, which bearing is united with the central shaft of the Tripod by a swivel, so that it will revolve horizontally, without changing the position of the Tripod.

HORIZON.

The Horizon is also composed of metal, and it is so fitted to the Meridian at its horizontal diameter, THAT IT MAY BE CONVENIENTLY REMOVED AND REPLACED. Upon it is a Map containing the Signs of the Ecliptic and their divisions

into degrees, the Months of the Year and their divisions into Days, the Cardinal and Minor Points of the Compass and the degrees of Azimuth and Amplitude.

THE GLOBE.

The Globe itself *which is twelve inches in diameter*, is constructed of materials that are tough, light, durable and not perceptibly effected by any climatic changes of temperature. It is skillfully made, which in conjunction with the strength of the materials of which it is composed, renders its surface proof against change of form unless improperly used.

GLOBE MAP.

The Geographical Map with which this Globe is covered is issued by the Map Publishing House of W. & A. K. Johnston, Edinburgh, Scotland, and this is a sufficient guarantee that it has no superior. It is engraved in copper and printed in colors, and contains the Ocean Currents, the Isochimal and Isothermal lines, the latest Political Divisions and Boundaries of all Countries, the corrected Boundaries of the States and Territories of the United States, the Topography of various places and Countries as reported by modern Explorers, together with much new matter which is the outgrowth of both National and International enterprise. This array of additional knowledge, combined with that which the Map originally contained, gives to the Globe which it covers a value which many others do not possess.

GLOBE MOVEMENT.

The Axis of the Globe, unlike all others, is made of metal tubing, and in its ends are placed springs and bearings on which it revolves. The outer ends of these bearings are grooved so as to receive the inner edge of the Meridian, and they move on it when a change in the position of the axis of the Globe is desired, *a novel and very convenient device for this purpose.*

HOUR INDICES.

The Hour Indices, which are placed around the Poles of the Globe are stamped out of sheet brass and nickel-plated. Each Index is divided into twenty-four equal parts, and these parts have associated with them characters that represent the hours of the day.

QUADRANT OF ALTITUDE.

The Quadrant of Altitude is a flexible strip of metal graduated into equal parts, each corresponding in length to a degree on the Globe, and bent when in use so as to closely fit its surface.

THE ANALEMMA.

The Analemma on the Globe is a diagram which extends across the Torrid Zone. It contains the days of each month in the year, so arranged, that if the month and day of the month are given, the Declination of the Sun at that time may be readily found, or if the Declination of the Sun is given, the month and day of the month may be readily found, and

the Sign and the degree of the Ecliptic in which he is, also, the Equation of time, or the difference between Sun and Clock time for any day of the year.

THE STAR GLOBE is manufactured by Skillful Mechanics IN THE MOST SUBSTANTIAL MANNER, and an EXACT DUPLICATE of any part of it can be obtained at any time by applying to the Patentee.

A MANUAL containing a comprehensive series of Problems, Examples and Illustrations will accompany each Globe.

PROBLEMS AND EXAMPLES.

Problem I.

To find the Longitude and Latitude of any given place.

See Definitions 46, 48.

Find the given place on the Globe and adjust the Globe so that the Equator is directly under 0 of the Graduated Meridian, then bring the given place to the Meridian and the degree expressing the Longitude of the given place is found on the Globe directly under 0 and the number of degrees counted on the Meridian from 0 to the given place is its Latitude.

Note.—For the sake of brevity the word "Meridian" is used instead of "Graduated Meridian".

Examples.

1. What is the Latitude of the Cape of Good Hope?
2. What is the Latitude of St. Petersburgh?
3. What is the Longitude of Pittsburgh?
4. What is the Longitude of Calcutta?
5. What places have the greatest Latitude?
6. What places have no Latitude?

Problem II.

Two places being given, to find their difference of Latitude.

See Definitions 22, 26.

Find the Latitude of each place by Problem I. and if both places are on the same side of the Equator, subtract the less

number of degrees of Latitude from the greater and the remainder will be the difference of Latitude; but if the Latitude of one of the places is North of the Equator and that of the other South of the Equator, add them together and their sum will be the difference of Latitude.

Examples.

1. What is the difference of Latitude between New Orleans and Memphis?
2. What is the difference of Latitude between the Tropic of Cancer and the Tropic of Capricorn.
3. What places have the greatest difference of Latitude.

Problem III.

To find all those places that have the same Latitude or the same Longitude with a given place.

Find the given place on the Globe and adjust the Globe so that 0 of the Meridian is directly over the Equator; then bring the given place to the Meridian and the degree expressing the Longitude of the place is found on the Globe directly under 0, and all other places having the same Longitude will be under the same Meridian, and all other places having the same Latitude as that of the given place will pass under the degree on the Meridian expressing the Latitude of the given place by revolving the Globe once on its axis.

Examples.

1. What is the Longitude of Lexington?
2. What other places have nearly the same Longitude as Lexington?
3. What is the Longitude of Hong Kong?
4. What other places have nearly the same Longitude as Hong Kong?
5. What places have no Longitude?
6. What places have the greatest Longitude?

Problem IV.

Two places being given, to find their difference of Longitude.

See Definition 21, note 3d, also 26 and notes.

Find the Longitude of each place by Problem III. and if both places are East or both West of the Prime Meridian, subtract the less number from the greater for the difference of Longitude, but if one place is East and the other West of the Prime Meridian, add them together and their sum, if it be less than 180 degrees, will be the difference of Longitude; if the sum exceeds 180 degrees, subtract it from 360 degrees for the difference of Longitude.

Note.—"Prime Meridian" is the Meridian from which Longitude is measured East or West, 180 degrees.

Examples.

1. What is the difference of Longitude between Constantinople and Yokohama?

2. What is the difference of Longitude between Washington and Madras?

3. What is the difference of Longitude between Santa Fe and Hong Kong.

Problem V.

The Latitude and Longitude of a place being given, to find the place.

Adjust the Globe so that 0 on the Meridian is directly over the Equator and revolve the Globe on its axis till the given Longitude is under the Meridian; then under the given number of degrees of Latitude marked on the Meridian North or South is the place required.

Examples.

1. Find the Island whose Latitude is 65 degrees North and Longitude 20 degrees West.

2. Find the Island whose Latitude is 42 degrees South and Longitude 145 degrees East.

3. Find the Cape whose Latitude is 56 degrees South and Longitude 64 degrees West.

Problem VI.

To find the distance between two places.

Place 0 of the Quadrant over one of the places and extend it to the other place and the number of degrees between the places will be the distance in degrees, which, multiplied by 60 will

give the distance in Geographical miles, or multiplied by 69.1, will give the distance in Statute miles.

NOTE.—For the sake of brevity, the word Quadrant is used instead of "Quadrant of Altitude."

EXAMPLES.

1. What is the distance in degrees and in Geographical miles between Philadelphia and San Francisco?
2. Find the distance in degrees between the Falkland Islands and the Equator.
3. What is the distance in degrees from St. Helena to Cape Verd, via Monrovia?

PROBLEM VII.

To Rectify the Globe for any given place.

See Definitions 40, 41, 42 and notes.

Elevate the corresponding Pole as many degrees from the Horizon as the given place is distant from the Equator, then the Equator and Parallels of Latitude and Circles of Daily Motion will have their proper inclination in respect to the Horizon.

NOTE.—Circles of Daily Motion are the circles which the heavenly bodies seem to describe as the Earth turns on its axis.

EXAMPLES.

1. Rectify the Globe for a place whose Latitude is 60 degrees North.
2. Rectify the Globe for a place whose Latitude is 30 degrees South.

Problem VIII.

To find the Antœci of a given place.

See note below.

Find the Latitude of the given place by Problem I. and then under the same Meridian find the same degree of Latitude in the opposite Hemisphere and it will be the place required.

Note.—The Antœci are the inhabitants of the Earth who are located in the same Longitude, but in opposite Latitudes; hence in opposite Hemispheres.

Examples.

1. Required the Antœci of Northern Abyssinia
2. Required the Antœci of Barca.

Problem IX.

To find the Periœci of a given place.

See note below.

Find the given place and its Latitude and bring the place to the Meridian; then turn the Globe on its axis through 180 degrees and under the Meridian in the same Latitude as that of the given place, is the place required.

Note.—The Periœci are the inhabitants of the Earth who are located in the same Latitude, hence in the same Hemisphere but differing in Longitude 180 degrees.

Examples.

1. Required the Periœci of Western California.
2. Required the Periœci of Trinidad Island.

Problem X.

To find the Antipodes of a given place.

See notes below.

Find the place and its Latitude and bring the place to the Meridian; then revolve the Globe through 180 degrees and in the opposite Hemisphere under the Meridian and at a distance from the Equator equal to the Latitude of the given place is the place required.

Note.—Antipodes are the inhabitants of the Earth who are located at the opposite extremities of any one of its diameters.

Note.—Places situated on the Equator have no Antœci and their Periœci are their Antipodes. The Poles have no Periœci and their Antœci are their Antipodes.

Examples.

1. Required the Antipodes of Sumatra.
2. Required the Antipodes of Central Greenland.

Problem XI.

To find places equally distant from a given place.

See Definition 15.

Place 0 of the Quadrant on the given place as a center of motion and move it around this center on the surface of the Globe, and all places over which the same degree of the Quadrant moves are equally distant from the given place.

Examples.

1. Find two places equally distant from Cincinnati.
2. Find three places equally distant from St. Louis.

Problem XII.

The Latitude of a place, its distance and general direction from a given place being given, to find the place whose Latitude is given.

If the distance is given in miles, convert the miles into degrees, then place 0 of the Quadrant on the given place and move the other end of it Eastward, if the required place is Eastward or Westward, if the required place is westward, till the degree marked on it representing the distance arrives at the Parallel of Latitude indicating the Latitude of the place, and this point will be the place required.

Examples.

1. Find the place whose Latitude is 42 degrees North and distant from Baltimore in a North-western direction 9 degrees.
2. Find the place whose Latitude is $22\frac{1}{2}$ degrees South and distant from Quito in a South-eastern direction 42 degrees.

Problem XIII.

The Longitude of a place, its distance and general direction from a given place being given, to find the place whose Longitude is given.

Reduce the distance, if given in miles, to degrees, then place 0 of the Quadrant upon the given place and move the other end Northward, if the required place lies

Northward, or Southward if the required place lies Southward, till the degrees marked on it representing the distance arrives at the given Meridian and this point will be the place required.

Examples.

1. Find the place whose Longitude is 90 degrees West and distant in a North-eastern direction from the City of Mexico 14 degrees.

2. Find the place whose Longitude is 20 degrees East and distant in a South-western direction from Zanzibar 34 degrees.

Problem XIV.

Any Parallel of Latitude being given, to find how many miles make a degree of Longitude on it.

Place the Quadrant on the given Parallel and note the number of degrees intercepted between two Meridians 15 degrees apart, then multiply this number by 4 if Geographical miles are required, or by 4.6 if Statute miles are required.

Note.—It will be seen that if the distance between two Meridians 15 degrees apart be measured on the Equator, it will also measure 15 degrees on the Quadrant, and this number multiplied by 4 will give 60 the number of Geographical miles in a degree, or if multiplied by 4.6 it will give 69, nearly the number of Statute miles in a degree. As we go toward the Poles, the degrees of Longitude become smaller, and while these same Meridians will still be distant from each other 15 degrees of Longitude, the distance measured on the Quadrant, which is a uniform standard, will be less than 15 and this smaller number multiplied by the same multiplier 4 or 4.6, will give a smaller result.

Examples.

1. How many Geographical miles are in one degree on the Tropic of Cancer?
2. How many Statute miles are in one degree on the Antarctic Circle?

Problem XV.

To find at what rate per Hour any point on the Earth's surface moves by its axial rotation.

See Definition 5th.

If the point is situated on the Equator, reduce 15 degrees to miles for the rate per hour, but if it is located between the Equator and either Pole, then find by Problem XIV. the number of miles that make a degree of Longitude in the Latitide of the given place, which number multiplied by 15 will give the rate per hour.

Examples.

1. At what rate per hour do the inhabitants of Rio de Janeiro move by the rotation of the Earth on its axis?
2. At what rate per hour do the inhabitants of Hammerfest move by the rotation of the Earth on its axis?

Problem XVI.

To illustrate a Right Sphere.

See Definition 1, 51.

Adjust the Globe so that its axis will coincide with the plane of the Horizon, then the Equator, Parallels and Circles of Daily Motion will be perpendicular to the Horizon.

Examples.

1. Where would we have to be located on the Earth that it might be to us a Right Sphere?
2. What is the length of the days and nights at the Equator?
3. Could all the Stars in the Heavens be seen from the Equator in the course of a year?
4. How long would the Sun appear North, and South of the Equator during the year?

Problem XVII.

To illustrate a Parallel Sphere.

See Definition 52.

To illustrate a Parallel Sphere, adjust the Globe so that its axis is perpendicular to the plane of the Horizon, then the Equator, Paralells and Circles of Daily Motion will be parallel to the Horizon.

Examples.

1. Where would we have to be located on the Earth that it might be to us a Parrallel Sphere?
2. How long would there be constant day at each Pole?

Problem XVIII.

To illustrate an Oblique Sphere.

See Definition 53.

Adjust the Globe so that its axis will be oblique to the plane of the Horizon, then the Equator, Paralells and Circles of Daily Motion will also be oblique to the Horizon.

Examples.

1. Where would we have to be located on the Earth that it might be to us an Oblique Sphere?
2. Show how the days and nights increase and decrease in length on an oblique sphere.
3. Show why the longest day in the North Temperate Zone occurs in June and the shortest day in December.

Problem XIX.

To find the Sun's place in the Ecliptic on any given day of the Year.

See Definition 23 and note, also Def. 24.

Find the given day in the Circle of Months on the Horizon and opposite this day in the Circle of Signs will be found the Sign and degree representing the Sun's Longitude, then find the same Sign and Degree in the Ecliptic on the Globe, which will show the Sun's place as required.

Examples.

1. Find the Sun's place in the Ecliptic on the 1st day of May.
2. Find the Sun's place in the Ecliptic on the 25th of October.

Problem XX.

See Definition 49 and notes, also Def. 62.

To find the Sun's Longitude, Right Ascension and Declination for any given day in the year.

Adjust the Globe so that 0 of the Meridian is over the Equator, then find the Sun's Longitude by Problem XIX.

and turn the Globe on its axis till the Sun's place on the Ecliptic representing the Sun's Longitude arrives at the Meridian. Over this degree on the Meridian is the degree showing the Sun's Declination, and the distance counted from the First point of Aries on the Equator to the Meridan passing through the degree found on the Ecliptic, is the Sun's Right Ascension.

NOTE—The number of degrees expressing the Sun's Declination subtracted from 90 degrees gives the Polar Distance.

EXAMPLES.

1. Find the Sun's Longitude, Declination and Right Ascension on the 20th of August.
2. Find the Sun's Longitude, Declination and Right Ascension on the 1st of December.

PROBLEM XXI.

To find on what two days of the year the Sun will be vertical at any given place within the Tropics.

See Definitions 31, 32.

Adjust the Globe so that 0 of the Meridian is over the Equator, then find the Latitude of the given place on the Meridian and revolve the Globe on its axis till two points on the Ecliptic pass under the degree of Latitude already found on the Meridian. Then note the Signs and Degrees on the Ecliptic where these points are, and on the Horizon find the Signs and Degrees corresponding to them, and exactly opposite the two numbers of degrees, in the Circle of Months, are the days required.

Examples.

1. On which two days of the year will the Sun be vertical 20 degrees North of the Equator?
2. On which two days of the year will the Sun be vertical 10 degrees South of the Equator?

Problem XXII.

To find the difference of time between any two places which are not under the same Meridian.

Revolve the Globe on its axis till the place that lies Eastward of the other place arrives at the Meridian and set the Hour Index at XII. Revolve the Globe Eastward till the place that lies West comes to the Meridian, then the number on the Hour Index under the Meridian will be the number of hours required.

Examples.

1. Find the difference in time between Greenwich and Guayaquil.
2. Find the difference in time between Columbus and Lake Tchad.

Problem XXIII.

The hour being given at any place, to determine what hour it is at any other given place.

Find the difference of time between the two places by Problem XXII. then if the place whose time is required is East of the place whose time is given, add this difference to the given time, but if the place whose time is required is West, subtract

this difference from the given time, and the result will be the time required.

Examples.

1. If it is 10 o'clock A. M. at Madrid what time is it at Rome?
2. If it is 4 o'clock P. M. at Charleston what time is it at Richmond?

Problem XXIV.

To find the time of the Sun's rising and setting on any given day at a place whose Latitude is given.

Find the Declination of the Sun by Problem XX. and elevate the pole corresponding to the Sun's Declination as many degrees as that of his Declination, and bring the given place to the Meridian and set the Hour Index at XII. Then turn the Globe Westward on its axis till the given place comes to the Horizon, and the Hour Index will indicate the time of the Sun's rising, and by turning the Globe Eastward on its axis till the given place comes to the Horizon, the Hour Index will show the time of the Sun's setting.

Examples.

1. At what time does the Sun rise and set at Toronto on the 1st of March?
2. At what time does the Sun rise and set at Melbourne on the 1st of November?

Problem XXV.

To find all places where the Sun is vertical on a given day.

Find the Sun's Declination for the given day according to Problem XX. and revolve the Globe once on its axis, and all places on the Globe that have the Sun vertical on that day will pass under the degree on the Meridian that indicates the Sun's Declination for the given day.

Examples.

1. At what places is the Sun vertical on the 1st of July?
2. At what places is the Sun vertical on the 1st of January?

Problem XXVI.

The day and hour of the day at any place being given, to find where the Sun is vertical at that time.

See Definition 49 and notes, also Def. 80.

Find the Sun's Declination by Problem XX. and elevate the Pole corresponding to the Declination as many degrees as that of the Declination and bring the place on the Globe whose time is given to the Meridian and set the Hour Index at XII. Then revolve the Globe Westward, if the given time is before noon, or Eastward if the given time is past noon, through as many hours and minutes as it is before or past noon, and the point under 0 of the Meridian will be the required place.

Examples.

1. Where is the Sun vertical at 9 o'clock, A. M. on the 1st of June?

2. Where is the Sun vertical at 4 o'clock, P. M. on the 1st of September?

Problem XXVII.

To find the Month and Day of the month when the Sun's place in the Ecliptic is in any given Degree, in any given Sign.

Find on the Globe the Sign and Degree which show the Sun's place; then find the same Sign and Degree as marked on the Horizon and opposite this degree in the Circle of Months is the day required.

Examples.

1. Find the Month and Day of the month when the Sun will be in the 30th degree of Taurus.
2. Find the Month and Day of the month when the Sun will be in the 20th degree of Scorpio.

Problem XXVIII.

To find on a given day those portions of the Earth on which the Sun does not Rise or Set.

Find the Declination of the Sun by Problem XX. for the given day; then elevate the Pole corresponding with his Declination an equal number of degrees above the Horizon with that of his Declination. Revolve the Globe once Eastward on its axis and to all that portion of the Globe around the elevated Pole that does not descend below the Horizon the Sun does not set, and to all that portion of the Globe around the depress-

ed Pole that does not ascend above the Horizon the Sun does not rise.

EXAMPLES.

1. Find the regions of the Earth where the Sun neither rises nor sets on the 21st of December.
2. Find the regions of the Earth where the Sun neither rises nor sets on the 21st of June.

PROBLEM XXIX.

At any given place and on any given day of the Year, to find the length of the Day, and also of the Night.

Find the time of the Sun's rising and setting for the Latitude of the given place on the given day by Problem XXIV. then the length of the Day is found by doubling the time of the Sun's Setting, and the length of the Night is found by doubling the time of the Sun's rising.

EXAMPLES.

1. How many Hours Long is the Day, also the Night at Paris on the 20th of August?
1. How many Hours Long is the Day, also the Night at Montreal on the 20th of February?

PROBLEM XXX.

At any Given Place on any day of the Year, to find the Sun's Meridian Altitude and Zenith Distance.

See Definitions 55, 56, 57, 58, 59.

Elevate the Pole corresponding to the Latitude of the given

place as many degrees as that of the Latitude of the place, and find the Sun's place in the Ecliptic for the given day by Problem XIX. then bring the Sun's place to the Meridian and the number of degrees counted on the Meridian to the Horizon from the Sun's place is the required Altitude, and the difference between this number and 90 degrees is the Zenith Distance.

Examples.

1. Find the Sun's Meridian Altitude and Zenith Distance at Havannah on the 1st of November.
2. Find the Sun's Meridian Altitude and Zenith Distance. at Cincinnati on the 20th of April.

Problem XXXI.

To find the Sun's Altitude and Zenith Distance at any given hour of any given day at any given place.

Elevate the Pole corresponding to the Latitude of the given place as many degrees as that of the Latitude of the place, and find the Sun's place in the Ecliptic for the given day by Problem XIX. then bring the Sun's place to the Meridian and set the Hour Index at XII. Revolve the Globe Westward if the given time be before noon, or Eastward if the given time be after noon, through as many hours as the given time is before or after noon. This being done attach the Quadrant to the Zenith point of the Meridian and move the other end over the Globe till its graduated edge comes to the Sun's place, and the number of degrees counted on the Quadrant from the Horizon to the Sun's place will be the required Altitude, and the num-

ber counted from the Sun's place to the Zenith will be the Zenith distance.

Examples.

1. What is the Sun's Altitude and Zenith Distance at Berlin on the 10th of May at 2 o'clock P. M?

2. What is the Sun's Altitude and Zenith Distance at Buenos Ayres on the 20th of December at 11 o'clock A. M?

Problem XXXII.

To find the Hour of any given day at any given place when the Sun's Altitude is given.

Rectify the Globe for the Latitude of the place and find the Sun's Place in the Ecliptic by Problem XIX, then bring his place to the Meridian and set the Hour Index at XII. This being done attach the Quadrant to the Zenith point and move the other end over the Globe and at the same time revolve the Globe on its axis till the Sun's place and the degree on the Quadrant expressing the Sun's Altitude coincide, and the Hour Index will show the number of hours required before or after noon.

Examples.

1. When the Sun's Altitude at Aspinwall on the 15th of July is 30 degrees, what is the Hour of the Day?

2. When the Sun's Altitude at Sidney on the 16th of December is 50 degrees, what is the Hour of the Day?

Problem XXXIII.

To find the Bearing and distance of one place from another.

See Definitions 60, 71, 72, 73.

Elevate the pole that corresponds to the Latitude of one of the places to the Latitude of that place, and bring the place to the Meridian; then attach the Quadrant to the Meridian immediately over the place and carry the other end around on the surface of the Globe till its graduated edge touches the other place, and the Azimuth will give the bearing of the second place from the first, and the number of degrees counted on the Quadrant between the two Places multiplied by the number of miles in a degree will give the distance between the two places in miles.

Examples.

1. Find the Bearing and Distance of London from New York.
2. Find the Bearing and Distance of Cape Horn from the Cape of Good Hope.

Problem XXXIV.

To find that part of the Globe where the Sun ceases to rise and that part where he ceases to set on any given day.

Find the Sun's Declination by Problem XX. for the given day and elevate the corresponding Pole above the Horizon as many degrees as expresses his Declination; then revolve the Globe on its axis and the boundary of that portion of the Globe that does not descend below the Horizon shows the places where

the Sun has ceased to set, and the boundry of that portion of the Globe that does not rise above the Horizon shows the places where the Sun has ceased to rise.

Examples.

1. On what Parallel does the Sun cease to rise and also cease to set on the 25th of May?
2. On what Parallel does the Sun cease to rise and also cease to set on the 12th of November?

Problem XXXV.

To find when Twilight Begins, Ends and its Duration on any given day at any given place in the Torrid or Temperate Zones.

See Definitions 35, 36, 37, 43.

Find the Declination of the Sun for the given day by Problem XX. and elevate the Pole corresponding to the Declination of the Sun as many degrees as that of his Declination on the given day, and bring the given place to the Meridian and set the Hour Index at XII. Then revolve the Globe Eastward till the given place comes to the Horizon and the Hour Index will show the time at which the Sun sets and Twilight begins. Now attach the Quadrant to the Meridian at 0 and bring its graduated edge to the given place and continue to revolve the Globe till the Quadrant shows the given place to be 18 degrees below the Horizon, and the Hour Index will indicate when the evening twilight ends, and the difference between the hours of its beginning and ending will be its duration.

Examples.

1. At what Hour does the Sun set, and at what Hour does Twilight end at Vienna on the 6th of December?
2. At what Hour does the Sun set, and at what Hour does Twilight end at the Island of St. Helena?

Problem XXXVI.

To find the Sun's Azimuth and Amplitude at any given place for any given hour on any given day.

See Definition 61 and notes, also Def. 26 and notes.

Elevate the pole corresponding to the Latitude of the place as many degrees as that of the Latitude and attach the Quadrant to the Meridian at 0. Next find the Sun's place in the Ecliptic by Example XIX. and bring it to the Meridian and set the Hour Index at XII. Then if the time be before noon turn the Globe Eastward, or if it be afternoon, turn it Westward through as many hours as the time is before or after noon, and pass the Quadrant through the Sun's place on the Ecliptic, and the number of degrees counted on the Horizon from the North Point or from the South Point, if it be the nearer of the two, to the Quadrant will be the Azimuth, and the number counted from the East or from the West point, if it be the nearer will be the Amplitude.

Note.—It will be observed that the Azimuth and Amplitude are complements of each other, and if either be known the other may be found by subtracting the known number from 90 degrees.

Examples.

1. What is the Sun's Azimuth and Amplitude at Glasgow at 8 o'clock A. M. on the 10th of January?
2. What is the Sun's Azimuth and Amplitude at Valpariso at 3 o'clock P. M. on the 10th of June?

Problem XXXVII.

The Sun's Amplitude or Azimuth being given at any given hour of any given day to find the Latitude of the place of the observer.

Find the Sun's place on the Ecliptic for the given day by Problem XIX. and bring his place to the Meridian and set the Hour Index at XII. Then if the given time be before noon revolve the Globe Eastward, or if it be after noon revolve the Globe Westward, through as many hours as the given time is before or after noon. This being done attach the Quadrant to the Meridian at 0 and move the other end till it arrives at the given degree of Azimuth or Amplitude on the Horizon and retain it in this position; then without allowing the Globe to turn on its axis elevate or depress whichever pole requires it, till the Sun's place arrives at the Quadrant, and the elevation of the pole above the Horizon will show the Latitude of the place of the observer.

Examples.

1. If the Sun's Amplitude is 30 degrees North of the East point at 9 o'clock A. M. on the 5th of February, what is the Latitude of the Observer?

2. If the Sun's Azimuth is 45 degrees West of South at 4 o'clock P. M. on the 30th of July, what is the Latitude of the Observer?

Problem XXXVIII.

To find at what time the Sun will be due East or due West from any given place on any given day.

Rectify the Globe for the Latitude of the given place and find the Sun's place in the Ecliptic by Problem XIX. for the given day, and bring it to the Meridian and set the Hour Index at XII. Attach the Quadrant to the Meridian at 0 and move its other end on the surface of the Globe till its graduated edge arrives at the East point of the Horizon. Then revolve the Globe on its axis till the Sun's place arrives at the edge of the Quadrant, and the Hour Index will show the number of hours before noon when the Sun will be due East and at the same time past noon he will be due West.

Examples.

1. At what hour will the Sun be due East from Pittsburg on the 1st of April.
2. At what hour will the Sun be due West from Queen Charlotte Islands on the 5th of August?

Problem XXXIX.

To find that Part of the Equation of Time or difference between Clock and Sun Time, which depends on the Obliquity of the Ecliptic, for any given day.

See Definition 23 and note, also Def. 24.

Find the Sun's place in the Ecliptic for the given day by Problem XIX. and bring it to the Meridian; then find the number of degrees to the Meridian in the order of the Signs from the First point of the Sign Aries reckoned on the Equator and also on the Ecliptic, and subtract the less from the greater. Reduce this difference to minutes by multiplying by 4, as there are 4 minutes of time in a degree, and it will give the Equation of time.

NOTE.—If the number of degrees on the Ecliptic exceed those on the Equator the Sun time is faster than clock time, but if the number of degrees on the Equator exceed those on the Ecliptic, Sun Time is slower than Clock Time.

EXAMPLES.

1. What is the Equation of time on the 3d of November?
2. What is the Equation of time on the 15th of May?

PROBLEM XL.

At any given place in the North Frigid Zone, to find the beginning and end of constant day.

See Definitions 34, 38, 39.

Adjust the Globe so that the Equator is under 0 of the Meridian and bring the First point of Aries to the Meridian; then find the number of degrees expressing the Latitude of the place and subtract this number from 90 degrees and count on the Meridian Southward from the Equator the number of degrees expressing this difference, and note this number. Next revolve the Globe Westward on its axis, and observe in what Signs and at what Degrees the two points of the Ecliptic are that pass

under this number, and on the Horizon opposite the same Signs and Degrees taken in the same order are found the two days which are respectively the beginning and the end of constant day.

NOTE.—The same Solution may be used for any point in the South Frigid Zone by observing to reckon the difference of degrees Northward instead of Southward from the Equator.

EXAMPLES.

1. Find the Beginning, and End of constant day at Hammerfest.
2. Find the Beginning, and End of constant day 15 degrees South of the Antarctic Circle.

PROBLEM XLI.

The Month, Day and Hour of the day being given at any place, to find where the Sun is vertical, and all places that have noon, and all places that have midnight.

Find the Sun's Declination by Problem XX. and elevate the pole corresponding to his Declination as many degrees as that of his Declination and bring the given place to the Meridian and set the Hour Index at XII. Then if the given time be before noon revolve the Globe Westward through as many hours as it is till noon; but if the given time be after noon revolve the Globe Eastward through as many hours as it is past noon, and all places under the Meridian above the Horizon will have noon, and all places under the Meridian below

the Horizon will have midnight, and the point under 0 of the Meridian will be the place where the Sun is vertical.

Examples.

1. When it is Noon at Philadelphia on the 10th of April, at what particular place is the Sun vertical, what other places have noon, and what places have midnight?

2. When it is Midnight at Montevideo on the 10th of November, at what particular place is the Sun vertical, what other places have midnight, and what places have noon.

Problem XLII.

To find the Sun's Longitude and Declination by the Analemma for any given day.

See Analemma on the Globe.

Adjust the Globe so that the Equator is under 0 of the Meridian. Then find the given day on the Analemma and revolve the Globe till it arrives at the Meridian, and the degree on the Meridian over the given day will be the Sun's Declination.

To obtain the Sun's Longitude, find the point of the Ecliptic on the Globe which corresponds with the given day by Problem XIX. and the number of degrees counted on the Ecliptic Eastward from the First Point of the Sign Aries to the Sun's place, will be his Longitude.

Examples.

1. Find by the Analemma the Sun's Declination and Longitude on the 1st of June.
2. Find by the Analemma the Sun s Declination and Longitude on the 24th of November.

Problem XLIII.

To find by the Analemma on what two Days of the Year the Sun will be vertical at any given place within the Tropics.

Adjust the Globe so that 0 of the Meridian is over the Equator. Then find the Latitude of the given place on the Meridian and revolve the Globe on its axis till the Analemma arrives at the Meridian. Under the degree on the Meridian, showing the Latitude of the place, are found the required days.

Examples.

1. Find by the Analemma on what two Days of the Year the Sun will be vertical 15 degrees South of the Equator.
2. Find by the Analemma on what two days of the Year the Sun will be vertical 10 degrees North of the Equator.

Problem XLIV.

To find by the Analemma all places where the Sun will be vertical on a given day.

Adjust the Globe so as to bring the Equator under 0 of the

Meridian. Then find the given day on the Analemma and revolve the Globe till the Analemma arrives at the Meridian, and the degree on the Meridian over this day will show the Sun's Declination; and if the Globe, is made to turn once Eastward on its axis all places which pass under this degree of the Meridian will have a vertical Sun.

EXAMPLES.

1. Find by the Analemma all places where the Sun is vertical on the 1st of April.
2. Find by the Analemma all places where the Sun is vertical on the 1st of November.

PROBLEM XLV.

At any given place in the North Frigid Zone, to find by the Analemma the length of the longest day.

Adjust the Globe so that the Equator will be under 0 of the Meridian. Then find the Latitude of the given place in degrees and the Complement of the Latitude, which is the difference between its Latitude and 90 degrees. Count Northward from the Equator on the Meridian as many degrees as that of the Complement, and note the last degree. Then revolve the Globe on its axis till the Analemma arrives at the Meridian and the two days under this degree will show the beginning and end of the longest day.

EXAMPLES.

1. Find by the Analemma the length of the longest day 10 degrees North of the Arctic Circle.

2. Find by the Analemma the length of the longest day 20 degrees North of the Arctic Circle.

Problem XLVI.

Any place being given in the South Frigid Zone, to find by the Analemma the length of the longest day.

Adjust the Globe so that the Equator will be under 0 of the Meridian, and find the Latitude of the given place in degrees and its Complement. Then count Southward from the Equator on the Meridian the number of degrees equal to the Complement and note the degree where this number ends. Revolve the Globe on its axis till the Analemma comes under the Meridian and the two days under the degree noted will show the beginning and end of the longest day.

Examples.

1. Find by the Analemma the length of the longest day 5 degrees South of the Antarctic Circle.
2. Find by the Analemma the length of the longest day 15 degrees South of the Antarctic Circle.

Problem XLVII.

Any place being given in either of the Frigid Zones, to find by the Analemma the length of the longest night.

Adjust the Globe so that the Equator will be under 0 of the Meridian and subtract the number of degrees expressing the Latitude of the given place from 90, and count from the Equator Southward if the place be in the North Frigid Zone, or

Northward if the place be in the South Frigid Zone, the number of degrees expressing this difference, and note this number. Then revolve the Globe on its axis till the Analemma comes under the Meridian and the two days under the degree noted will show the beginning and end of the longest night.

EXAMPLES.

1. Find by the Analemma the length of the longest night at Spitsbergen Island.
2. Find by the Analemma the length of the longest night at Mt. Erebus.

PROBLEM XLVIII.

The longest and the shortest days in either Hemisphere being given, to find the width of the Torrid Zone.

Adjust the Globe so that 0 of the Meridian is over the Equator and find by the Analemma the Sun's Declination for the two given days, and the sum of these Declinations will be the width of the Torrid Zone in degrees, and its width in Geographical or Statute miles may be found by multiplying by 60 or 69.1.

EXAMPLES.

1. If the longest day in the Northern Hemisphere is the 21st of June and the shortest day the 22nd of December, what is the width of the Torrid Zone?
2. If the width of the Torrid Zone is 47 degrees, what is the width of each of the other Zones?

PROBLEM XLIX.

The time of the Occurrence of a Lunar Eclipse, in the mean Solar time of any place being given, and its duration, to find those parts of the Earth where the beginning and the end of the Eclipse are visible, and also those regions where the Eclipse is visible throughout its duration.

Find the Declination of the Sun by Problem XX. and elevate the pole corresponding to his Declination as many degrees above the Horizon as the Declination. Then bring the place from which the time is reckoned to the Meridian and set the Hour Index at XII. Turn the Globe Westward or Eastward according as the time is before or after noon through as many hours as the beginning of the Eclipse is before or after noon, and to all that Hemisphere below the Horizon the beginning of the Eclipse will be visible. Next turn the Globe Eastward through as many hours as are equal to the duration of the Eclipse and to all that Hemisphere now below the Horizon the end of the Eclipse will be visible, and to all those regions common to these two Hemispheres below the Horizon the Eclipse will be visible throughout its duration.

EXAMPLES.

1. If a partial Eclipse of the Moon begins at 7 o'clock P. M., Pittsburgh Time, on the 10th of November and lasts one hour, in what regions is it visible throughout its duration?

2. If an Eclipse of the Moon begins at 2 o'clock A. M. Washington time, on the 15th of July and lasts two hours, in what regions is it visible throughout its duration?

Problem L.

The time of the occurrence of a Solar Eclipse in the mean Solar time of any place being given, and its duration, to find those regions on the Earth in which it is visible.

Adjust the Globe so as to bring the Equator under 0 of the Meridian. Then find the declination of the Sun for the given day and note it. Next bring the place from which the time is reckoned to the Meridian and set the Hour Index at XII. Then turn the Globe on its axis Westward if the given time be before noon or Eastward if it be after noon, through as many hours as the beginning of the Eclipse is before or after noon. To that point on the Earth which is now under the degree on the Meridian corresponding to the declination of the Sun, the Sun will be vertical, and to all places within 35 degrees of this point the beginning of the Eclipse will be visible. Then turn the Globe Eastward on its axis through as many hours as are equal to the duration of the Eclipse and note where the Sun is vertical, and to all places within 35 degrees of this point the end of the Eclipse will be visible, and to all regions which are common to the two Areas thus found the Eclipse will be visible throughout its duration.

Examples.

1. If an Eclipse of the Sun begins at 10 o'clock A. M., New York time, on the 25th of August, and continues 30 minutes, in what regions is it visible throughout its duration?

2. If an Eclipse of the Sun begins at 3 o'clock P. M., Chicago time, on the 31st of October, and continues 50 minutes, in what regions is it visible throughout its duration?

DEFINITIONS AND EXPLANATIONS.

The Earth on which we dwell is the third primary planet of the eight that revolve around the Sun. Her mean distance from the Sun is about 91,430,000 miles and she revolves once around him in about 365¼ days, and rotates once on her axis in about 24 hours. The distance through her center from North to South, which is her Polar diameter, is about 7,899 miles, and the *mean* distance from any point of her Equator to the opposite point, which is her Equatorial diameter, is about 7,926 miles. In consequence of the difference of about 26½ miles in the lengths of these diameters, she is not a sphere, but an Oblate Spheroid, which means a sphere flattened on the opposite sides. *

1. A SPHERE is a solid or volume bounded by a surface, every point of which is equally distant from a point within, called the center.

2. THE RADIUS OF A SPHERE is a straight line drawn from the center to any point in the surface.

3. THE DIAMETER OF A SPHERE is a straight line drawn through its center and each end terminating in its surface.

* NOTE.—The earth's equatorial circumference is an ellipse whose major axis is 1⅔ miles longer than its minor axis.

4. THE AXIS OF THE EARTH is the diameter on which it turns once in about 24 hours, and the same imaginary line continued North and South until it meets the starry heavens constitutes the axis of the Celestial Sphere.

5. THE POLES OF THE EARTH are the extremities of the Earth's axis, and the POLES OF THE HEAVENS are the extremities of the Celestial axis.

6. A CIRCLE is a plane surface bounded by a curved line, every point of which is equally distant from a point within, called the center. *

7. THE CIRCUMFERENCE OF A CIRCLE is the line that bounds the circle.

8. THE RADIUS OF A CIRCLE is any straight line drawn from its center to its circumference.

9. THE DIAMETER OF A CIRCLE is any straight line passing through its center and each end terminating in its circumference.

10. AN ARC is any part of a circumference.

11. A PLANE is a surface such that if any two points be taken in it, a straight line joining these points will be wholly in the surface.

12. A CURVED SURFACE is a surface which is neither a plane nor composed of planes.

* NOTE.—The word CIRCLE, is used instead of circumference in describing lines on the surface of the globe.

NOTE.—The phrase, PLANE OF THE CIRCLE, is used to denote the CIRCLE proper.

13. A STRAIGHT LINE is one that does not change its direction at any point.

14. A CURVED LINE is one that changes its direction at every point.

15. A POINT is that which has position, but not magnitude.

16. PARALLEL LINES are such as have the same direction, and are therefore equally distant from each other at all corresponding points.

17. AN ANGLE is the opening or difference in direction between two lines which meet in a common point called the vertex.

18. A RIGHT ANGLE is one that is equal to 90 degrees and is the angle which may be formed by drawing a vertical and a horizontal radius in a circle.

19. AN ACUTE ANGLE is one that is less than a Right angle.

20. AN OBTUSE ANGLE is one that is greater than a Right angle. *

21. A GREAT CIRCLE is one which passes through the center of a Sphere and divides it into two equal parts. †

* NOTE.—OBLIQUE ANGLES, embrace the two proceding classes, Obtuse and Acute.

† NOTE.—For the sake of convenience, both the Earth and the Heavens are conceived to be marked by Points and divided into parts by Lines and Circles, whose Planes cut through them in various directions.

NOTE.—Every Circle, great or small is conceived to be divided into 360 equal parts called degrees, therefore a degree is not a fixed quantity, but only an aliquot part of any Citcle.

22. THE EQUATOR is a great Circle which cuts the Earth at Right angles with its Axis, and divides it into the Northern and Southern Hemispheres.

NOTE.—The intersection of the PLANE of the Equator with the surface of the Earth, constitutes the Terrestrial Equator, and with the concave Sphere of the Heavens the Celestial Equator or the Equinoctial.

23. THE ECLIPTIC, is a great Circle in which the Earth performs her annual revolution around the Sun, and also in which is the apparent path of the Sun.

NOTE.—The Orbit of the Earth, is her pathway in the Ecliptic.

24. THE OBLIQUITY OF THE ECLIPTIC is the inclination of the Ecliptic to the Equinoctial of about $23\frac{1}{2}$ degrees.

25. THE EQUINOCTIAL POINTS are the intersections of the Ecliptic and Eqninoctial.

NOTE.—In consequence mainly of the Solar and Lunar attraction upon the excess of matter around the Equator of the Earth, it is slightly disturbed in its yearly motion, causing the intersections of the Ecliptic with the Equinoctial to move westward about 50″ annually.

26. MERIDIANS are great Circles, which pass through the North and South points, and cross the Equator at Right angles.

NOTE.—THE FIRST OR PRIME MERIDIAN, is the Meridian from which Longitude is reckoned East or West. Longitude is sometimes reckoned from the Meridians of Ferro, Paris, Madrid and Washington, but usually from the Meridian of Greenwich, England.

NOTE.—The word Meridian frequently denotes the upper half of a great Circle, which passes through the North and South points.

NOTE.—Meridians are sometimes called Hour Circles, and also lines of Longitude, because the Arcs of the Equator intercepted between them, are used as measures of Time and Longitude.

27. THE EQUINOCTIAL COLURE is the Meridian which passes through the Equinoctial points.

28 The Solstitial Colure is the Meridian which passes through the Solstitial points.

THE SOLSTITIAL POINTS are the points where the Ecliptic touches the Northern and Southern Tropics.

NOE.—The East and West points are equidistant from the Poles of the Earth, and are where the Sun rises and sets when the Days and Nights are equal.

29. A SMALL CIRCLE is one that divides a Sphere into two unequal parts, as it does not pass through the centre of the Sphere.

30. PÁRALLELS OF LATITUDE are small Circles, parallel to the Equator, and when extented into the Heavens, are called Parallels of Declination.

31. THE TROPIC OF CANCER is the Parallel of Latitude which touches the Northern point of the Ecliptic called the Summer Solstice.

32. THE TROPIC OF CAPRICORN is the Parallel of Latitude which touches the Southern point of the Ecliptic called the Winter Solstice.

32. THE ARCTIC OR NORTH POLAR CIRCLE is the Parallel of Latitude which passes through the Pole of the Ecliptic, distant about 23½ degrees from the North Pole.

34. THE ANTARCTIC OR SOUTH POLAR CIRCLE is the parallel of latitude which passes through the Pole of the Ecliptic, distant about 23½ degrees from the South Pole.

35. TORRID ZONE, is that portion of the Earth's surface which lies between the Tropics.

36. THE NORTH TEMPERATE ZONE is that portion of the Earth's surface which lies between the Tropic of Cancer and the Arctic Circle.

37. THE SOUTH TEMPERATE ZONE, is that portion of the Earth's surface which lies between the Tropic of Capricorn and the Antarctic Circle.

38. THE NORTH FRIGID ZONE is that portion of the Earth's surface which lies North of the Arctic Circle.

39. THE SOUTH FRIGID ZONE is that portion of the Earth' surface which lies South of the Antarctic Circle.

40. THE SENSIBLE HORIZON is a Circle touching the Earth at the spectators feet and extending to the Heavens.

41. THE VISIBLE HORIZON is the line where the Sky and Earth seem to meet, forming a Circle around the spectator.

42. THE RATIONAL HORIZON is a Great circle which is parallel to the Sensible Horizon and distant from it nearly 4,000 miles, the semi-diameter of the Earth, and divides the Earth into upper and lower Hemispheres and separates the visible Heavens from the invisible.

NOTE.—In consequence of the vast distance to the Starry Sphere, these Horizons seem to coincide in it, so that we see the same Hemisphere of stars that we would see if the upper half of the Earth were removed and we were standing on the Rational Horizon.

NOTE.—Every place on the Earth has its own Horizon.

43. Refraction of Light is the deflection of the rays from their original course, by the medium through which they pass.

44. The Cardinal Points when referred to the Earth are North, South, East and West, when referred to the Heavens are the Zenith and Nadir, and when referred to Ecliptic, they are the Equinoxes and Solstices.

45. The Mariners Compass is composed of a Magnetic Needle, free to move on a sharp-pointed support erected in the centre of a Dial which is divided into thirty two equal parts representing the Cardinal and Intermediate points of the Horizon.

46. The Latitude of a place on the Earth is its distance measured on its Meridian North or South from the Equator.

47. The Polar distance of a place on the Earth is its distance measured on its Meridian from the nearest Pole.

Note.—Latitude and Polar distance are mutually complements of each other, as each is measured on the same Meridian, in opposite directions, just 90 degrees.

48. Longitude is distance measured on the Equator or a Parallel from some Standard Meridian, called the First or Prime Meridian, East or West, from 0 to 180 degrees.

49. RIGHT ASCENSION is distance Eastward from the First Point of the Sign Aries, measured on the Equinoctial from 0 to 360 degrees.

NOTE.—The Declination of a heavenly body, is its distance North or South from the Equinoctial.

NOTE.—DECLINATION corresponds to Terrestrial Latitude.

NOTE.—The Polar distance of a Star, is the complement of its Declination.

50. The Zodiac is that part of the Celestial Sphere which lies about 8 degrees on each side of the Ecliptic.

51. A RIGHT SPHERE is one whose Axis lies wholly in the Plane of the Horizon, hence the Equator, Parallels and Circles of daily motion, are perpendicular to the Horizon.

52. A PARALLEL SPHERE is one whose Axis is perpendicular to the Plane of the Horizon, hence the Equator coincides with the Horizon, and the Parallels and Circles of a daily motion, are Parallel with the Horizon.

53. AN OBLIQUE SPHERE is one whose Axis is oblique to the Horizon, hence the Equator, Parallels and Circles of daily motion, are oblique to the Horizon.

Note.—The definitions of the different Points, Lines and Circles which are used in Astronomy, and the propositions based upon them, compose the DOCTRINE OF THE SPHERE.

54. THE POLES OF THE HORIZON are the Zenith and Nadir.

55. THE ZENITH is that point in the Celestial Sphere, directly over the observers head.

56. THE NADIR is that point in the Celestial Sphere, directly under our feet.

57, A VERTICAL CIRCLE is one that passes through the Zenith and Nadir and is perpendicular to the plane of the Horizon.

58. THE ALTITUDE OF A HEAVENLY BODY is its elevation above the Horizon, measured on a vertical circle.

59. THE ZENITH DISTANCE OF A HEAVENLY BODY is the complement of its altitude, that is the difference between the altitude and 90 degrees.

60. THE AZIMUTH OF A HEAVENLY BODY is the angular distance between the plane of the Meridian and that of a vertical circle passing through the body, and both passing through the Zenith.

NOTE.—Azimuth is reckoned on the Horizon East or West from the North and South points, from 0 to 90 degrees.

61. THE AMPLITUDE OF A HEAVENLY BODY is the angular distance from the Prime Vertical to a vertical circle passing through the body.

NOTE.—Amplitude is reckoned on the Horizon North or South from the Prime Vertical, from 0 to 90 degrees.

NOTE.—Azimuth and Amplitude are mutually complements of each other, as each is measured on the same great circle in opposite directions just 90 degrees.

62. CELESTIAL LONGITUDE is angular distance East from the first point of the Sign Aries, measured on the Ecliptic from 0 to 360 degrees.

63. CELESTIAL LATITUDE is angular distance measured on a Secondary from the Ecliptic, from 0 to 90 degrees.

64.—THE AXIS OF A GREAT CIRCLE is a straight line passing through its center at Right Angles to its Plane.

65. THE POLE OF A GREAT CIRCLE is the Point where its Axis cuts through the surface of the Sphere.

66. EVERY GREAT CIRCLE has two Poles, each of which is 90 degrees from the Great Circle.

NOTE.—A GREAT CIRCLE which passes through the Pole of another Great Circle, cuts the latter at Right Angles and is called a SECONDARY to that Circle.

NOTE.—MERIDIANS are Secondaries to the Equator.

67. PERIHELION is that point in the Earth's Orbit nearest the Sun.

68. APHELION is that point in the Earth's Orbit farthest from the Sun.

69. THE LINE OF THE APSIDES is the line joining the Perihelion and Aphelion points.

70. ANGULAR DISTANCE is the difference in direction between two points as seen from a third point.

71. ANGULAR MOTION is the motion of a point or body around another point which is at rest.

72. ANGULAR VELOCITY is the rate of angular motion.

NOTE.—We ascertain the position of a given place on the Globe or in the Heavens, by taking its angular distance from two Great Circles, the Horizon and the Meridian, or the Horizon and the Prime Vertical, they being Coordinate Circles are used for such measurements.

73. THE AUTUMNAL EQUINOX is the time when the Sun crosses the Equator in going Southward, which occurs about the 22d of September.

74. THE VERNAL EQUINOX is the time when the Sun crosses the Equator in returning Northward, which occurs about the 21st of March.

75. THE SOLSTITIAL POINTS are the two points of the Ecliptic most distant from the Equinoctial.

76. THE SUMMER SOLSTICE is the time when the Sun is at his greatest distance North of the Equinoctial, which occurs about the 21st of June.

77. THE WINTER SOLSTICE is the time when the Sun is at his greatest distance South of the Equinoctial, which occurs about the 22d of December.

78. THE CIRCLE OF PERPETUAL APPARITION is the boundary of that space in the Heavens around the elevated Pole in which the Stars never set.

79. THE CIRCLE OF PERPETUAL OCCULTATION is the boundary of that space in the Heavens around the depressed Pole in which the Stars never rise.

SIGNS AND CONSTELLATIONS OF THE ZODIAC.

80. The Ecliptic is divided into 12 equal arcs of 30 degrees each, called Signs, and beginning at the Vernal Equinox they succeed each other Eastward in the follow- order: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces.

These 12 arcs of the Ecliptic are supposed to have corresponded about 2,200 years ago, with 12 constellations having the same names. But in consequence of

the retrograde motion of the Equinoc Points, the *Signs* of the Ecliptic have left the constellations with which they were formerly associated. As their motion corresponds with that of the Equinoctial Points, they have moved Westward about one whole Sign in the period referred to, so that the division of the Ecllptic called Aries lies in the constellation Pisces and the Sign Taurus in the constellation Aries and the Sign Gemini in the constellation Taurus, &c. Hence at the present time the names of the *constellations* of the Zodiac, North of the Equinoctial, commencing at the Vernal Equinox, are Pisces, Aries, Taurus, Gemini, Cancer, Leo and continuing in the same order, those South of the same Great Circle, are Virgo, Libra, Scorpio, Sagittarius, Capricornus and Aquarius.—See Chart on the Base of the Lunatellus Globe.

Letters representing the principal parts of the Lunatellus Globe.

A, The Arm which carries the Earth and Moon.

F, The Semi-circle, representing the plane of the Ecliptic.

C, The Circle of Illumination. I, The Calendar Index.

H, The Hour Index, B, The Base.

Q, The Quadrant. S, The Sun.

M, The Moon. E, The Earth.

D, The Cap which carries the Sun.

Directions for putting the parts together.

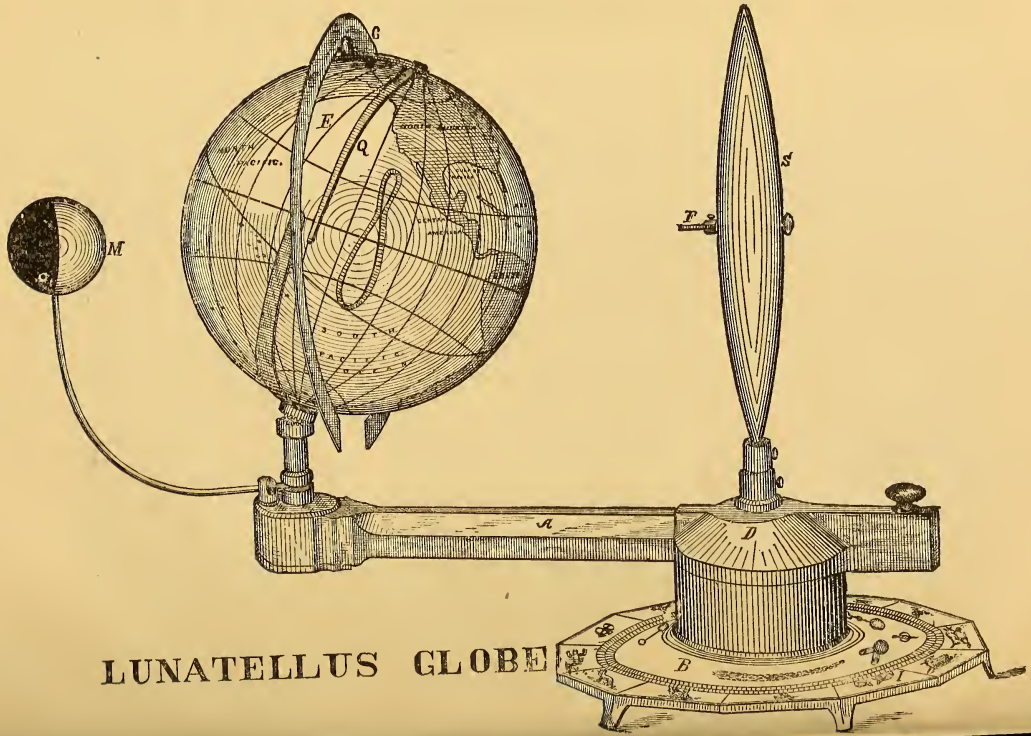
1st. Place the rear end of the Arm A in the Cap D and tighten the screws in the Cap. Then revolve the gear in the Arm A with the fingers, till the central axis of the Globe over which we place its tubular axis, inclines directly towards the center of the Cap D.

2nd. Place the Cap D on the central part of the Base B, with the Arm A directly over the word Solstice, June 21st, and fasten the Cap, Arm and Base together with the bolt which contains a thumb nut.

3rd. Place the tubular axis of the Globe on its central axis which is carried by the Arm A, so that the gear on the upper end of the standard, fixed in the outer end of the Arm A and the gear connected with the South Pole of the Globe, will come together; observing at the same time to have the outer ends of the yoke extending from the South Pole equally distant from the center of the Cap D.

4th. Place the Hour Index on the North end of the tubular axis of the Globe, and attach with a screw to the central axis of the Globe, the small metal bearing, containing a square hole in one end and a knob with a groove in it loosely pivoted in the other end; observing to incline the bearing in putting it on directly away from the center of the Sun when it is in place, and then put the inner edge of the Circle of Illumination in this groove, as it is being connected to the Instrument by the pivots of the yoke.

5th. Finally, place the Sun S with the Semi-circle F attached, at right angles with his Polar axis, on the center of the Cap D, and adjust the Moon Rod as the parts at the outer end of the Arm A suggest, and the Apparatus will be ready to operate.



LUNATELLUS GLOBE

LUNATELLUS GLOBE.

The Lunatellus Globe is the only *device in existence* which *faithfully* illustrates the mutual relations and various movements of the Sun, Earth and Moon. It is composed wholly of Iron Brass and Steel, except the *Terrestrial Globe* which represents the Earth, and the Chart that covers the Base.

BASE AND CHART.

The Base of the Instrument is cast in one piece and has placed upon it a Chart showing how the Sun, Earth and Moon perform their functions, as members of the Solar System, every day and hour in the Year.

The Chart contains in their proper relations, the Signs of the Zodiac, the months and days of the Year, the various lengths of the Seasons, the periods when the Sun is fast and slow, the degrees of Celestial Longitude, the Perihelion, Aphelion, Solstitial and Equinoctial points, together with other Symbols relating to the various movements of the Apparatus.

SUN AND SEMI-CIRCLE.

The Sun is represented by a body composed of Brass and connected by one of its Poles to the gearing within. To the Equator of this body is attached a Semi-circle which, when properly adjusted represents the Plane of the Ecliptic.

EARTH.

The Earth is represented by a *Terrestrial Globe, twelve inches in diameter,* and is pivoted by the South Pole to the gearing which gives it rotary motion.

MOON.

The Moon is represented by a Globe relative in size to that of the Terrestrial Globe, and is attached at one of its Poles to the outer end of a bent rod, the inner end of which is loosely pivoted to an upright placed on a disk which revolves, carrying the Moon around the Earth and and causing her to cross and recross the plane of the Ecliptic at an angle of about 5 degrees, as both Earth and Moon revolve around the Sun.

CIRCLE OF ILLUMINATION.

The Circle of Illumination is a flat Metallic Ring surrounding the Globe and loosely pivoted in the plane of the Equator, so that it is at liberty to change its position *every moment* as the Globe revolves around the Sun.

NOTE.—This is the only Invention which produces this result in a natural way.

CALENDAR INDEX.

The Calendar Index is located in the Arm A that carries the Earth and Moon around the Sun, and it can be set in a moment by revolving the Arm, so as to point to any day of any month, or any day of the Year.

QUADRANT OF ALTITUDE.

The Quadrant of Altitude is a flexible strip of Metal graduated into equal parts, each corresponding in length to a degree on the Terrestrial Globe and bent when in use so as to closely fit its surface.

GEARING.

This Apparatus is operated by Brass and Steel *Gear-wheels*, some of which are inside of the case and some enclosed in the outer end of the Arm that carries the Earth and Moon around the Sun.

UTILITY AND ECONOMY.

The principles of Geography and the various *positions, motions and phenomena* of the Sun, Earth and Moon are expressed by this Instrument with *such precision and accuracy* that more can be learned with its use in a few lessons, than can be learned in months without it, hence its necessity in every School and Family.

THE LUNATELLUS GLOBE is manufactured by skillful Mechanics *in the most sustantial manner*, and an *exact duplicate* of any part of it may be obtained at any time, by applying to the Patentee.

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